From Milk to Bones, Moving Calcium Through the Body

Calcium Kinetics During Space Flight

Did you know that when astronauts are in space, their height increases about two inches? This happens because the weightlessness of space allows the spine, usually compressed in Earth's gravity, to expand. While this change is relatively harmless, other more serious things can happen with extended stays in weightlessness, notably bone loss. From previous experiments, scientists have observed that astronauts lose bone mass at a rate of about one percent per month during flight. Scientists know that bone is a dynamic tissue — continually being made and repaired by specialized bone cells throughout life. Certain cells produce new bone, while other cells are responsible for removing and replacing old bone. Research on the mechanisms of bone metabolism and the effects of space flight on its formation and repair are part of the exciting studies that will be performed during STS–107.

During STS–60, astronaut Drew Gaffney (center) draws blood from Millie Hughes-Fulford (left) while James Bagian looks on.

Calcium plays a central role because 1) it gives strength and structure to bone and 2) all types of cells require it to function normally. Ninety-nine percent of calcium in the body is stored in the skeleton. However, calcium may be released, or *resorbed*, from bone to provide for other tissues when you are not eating.

To better understand how and why weightlessness induces bone loss, astronauts will participate in a study of calcium kinetics — that is, the movement of calcium through the body, including absorption from food, and its role in the formation and breakdown of bone. They will receive small amounts of special forms of calcium known as tracers. These allow scientists to trace the movement of calcium in the body. By tracking these tracers, we will see how calcium was processed and where it traveled in the body. Then, comparing the results from before, during, and after flight, we will learn how calcium metabolism changes when humans are in space.

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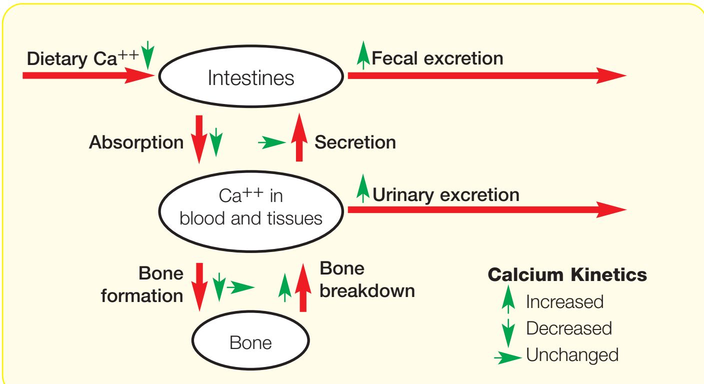
Earth Benefits and Applications

- Examining the role of vitamin D in calcium metabolism
- Understanding calcium kinetics
- Investigating the formation and resorption of bone
- Engineering healthy bone
- Preventing osteoporosis and other bone diseases
- Decreasing fractures.



This diagram shows the normal pathways of calcium movement in the body and indicates changes (green arrows) seen during preliminary space flight experiments.

Background Information

Science

Bones are living tissue, meaning that each day we build and break down bone. For this to occur we must provide adequate nutrition, including calcium, along with exercise. The preferred exercises are those that are weight bearing — walking, dancing, weight lifting, and other exercises that place weight on the legs. Astronauts exercise in space to try to keep their bones and muscles in shape. Despite this, bone loss still occurs, thereby providing an ideal laboratory to study the breakdown and rebuilding of bone and the path that calcium takes in reaching bone.

Dietary calcium is an important source of calcium for the body. The calcium is absorbed into your body from the food you eat and then stored in your bones.

Bone loss in microgravity has serious implications for bone health, including increased risk for bone fractures and kidney stones during flight and upon return to Earth. The bone loss experienced by astronauts in space is similar to the bone loss experienced by patients with osteoporosis or paralyzed individuals. To better understand calcium and bone changes during space flight, calcium kinetics and other aspects of bone and calcium metabolism will be measured. These measurements will be made before, during, and after flight. Information on the mechanisms of space-induced bone loss will be applicable to developing effective countermeasures for astronauts, and may help in developing treatments for osteoporosis or other bone-related diseases on Earth.

The calcium kinetics experiment will study how space flight affects calcium balance, calcium absorption, and bone resorption. This procedure requires that astronauts take two stable, non-radioactive forms of calcium (one orally and one intravenously). Samples of blood, urine, saliva, and feces (before and after flight only) will be collected and analyzed for the two calcium tracers. Using mathematical modeling techniques, scientists will determine the rates of calcium movement based on the tracer analyses. Specific parameters to be determined include the absorption of calcium from food, removal of calcium from the body, deposition of calcium in bone, and resorption of calcium out of bone.

Hormones, and other compounds which play a role in the control of bone and calcium metabolism, will also be measured to provide a more complete picture of the mechanisms involved. This study will deepen our understanding of calcium movement through the body, the effects of weightlessness on regulation of bone and calcium, and the recovery of these systems after return to Earth.

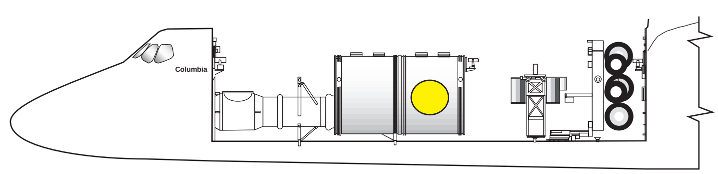
Operations

The calcium tracers will be administered before, during, and after flight, with biological samples collected for up to 10 days after each tracer administration. Biochemical, hormone, and other endocrine markers of bone metabolism will be measured from blood and urine samples. Food intake during flight will be recorded to measure the amount of calcium entering the body. Mathematical modeling techniques (developed by the National Institutes of Health) will be utilized to integrate the data and determine the movement of calcium through the body. Specifically, these analyses will determine the rates of calcium absorption, the rates of calcium excretion in urine and feces, and the rates of bone calcium deposition and resorption.

Earlier Results

Calcium loss has been measured since the *Skylab* missions of the 1970s, which showed that calcium excretion increased compared to preflight levels. Biochemical markers of bone also indicated that bone resorption was greatly increased during the *Skylab* missions.

Calcium studies continued during the *Mir* missions of the 1990s. *Mir* crewmembers showed 1) decreased vitamin D, a vitamin/hormone that plays an important role in calcium balance; 2) unchanged or decreased levels of osteocalcin and bone alkaline phosphatase, markers of bone formation; and 3) increased excretion of products from the breakdown of collagen, a major structural protein of bone. Since sufficient subjects are needed to obtain meaningful data, this research continues calcium kinetics studies performed previously on NASA-*Mir* and Shuttle-*Mir* missions.



Approximate location of this payload aboard STS–107.